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Present status of renewable energy resources in Jammu and Kashmir State of India

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ABSTRACT

Jammu and Kashmir State of India is one of the energy starved states despite of having tremendous potential for utilization of renewable energy. The natural energy sources like sunshine, wind, vegetation, water flow, biomass and other biological wastes are abundantly available in the state yet are not being potentially harnessed resulting in very low per capita energy availability forcing peoples to use wood resulting into deforestation. The fossils fuels, which pollute the environment, are extensively utilized even though they are not sustainable. Developing and properly implementing renewable energy technologies in this state can provide secure energy supply for rapid domestic and industrial development which will attract new investments, thereby creates additional employment. It shall also generate additional state income by allowing the state to sell renewable energy trading certificates to other states. Therefore, it is important that the region moves to clear and sustainable energy. This paper presents an overview of the present status of renewable energy development and summarizes key issues in each of the major industrial segments. It also examines crucial gaps in the renewable energy market, describes the goals set out by various government programs, and estimates the resources and effort required to meet these goals.

Contents

1. Introduction

The Indian economy is fully dependent on imports for all of its chemical fertilizer, petroleum and coal requirements. The growing population and small scale industries are pushing the use of traditional sources of energy (forest and agricultural waste) beyond the sustainable generation capacity of the existing forest and farm lands. Fossil fuels account for 90% of India's commercial energy use [1]. India has a very large potential for harnessing renewable energy sources and ranks fifth in the world in terms of installed renewable energy capacity, with more than 5% of the world's capacity in 2008 [2]. The Jammu & Kashmir State of India, which has the immense potential for the application of renewable energy projects. However, there is a wide gap between the estimated potential and the

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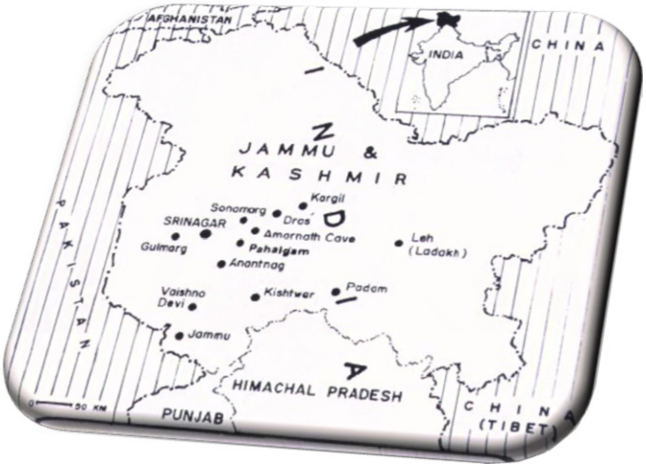


Fig. 1. Map of Jammu & Kashmir State of India.

cumulative achievements made so far [3]. The state is situated in the northern region of the Great Himalayan range spreading over 33–37°N latitude and 72–80°E longitude (Fig. 1). The state comprises 6.7% of the total geographical area of the country, covering over 2.22 lakh square km, of which about 30% is under cultivation.

Despite small geographical area, the state is blessed with diverse agro-climatic conditions, topography and natural resources for cultivation of a wide range of agro-horticultural crops [4]. The state consists of three regions: Jammu, Kashmir valley and Ladakh, which are diverse in culture, geography and climate. The Jammu region of J&K state (Fig. 2) bestowed wide range of agro-climatic conditions which provides enormous opportunity to grow sub tropical (<800 m amsl), sub temperate (801–1500 m amsl) and temperate (>1500 m amsl) crops. On the other hand the valley of Kashmir experiences temperate climate. Ladakh in contrast to both Jammu & Kashmir regions and is mountainous with scant vegetation and experiences high temperate and cold arid climate.

Different Agro climatic zones and livelihood production system in the state is presented in Table 1. The mean ambient temperature throughout the year ranges from 13 to 32 °C in Jammu region, 1.0 to 25 °C in Kashmir region and −8.0 to 17 °C in Leh region (Fig. 3). Low ambient temperature gives rise to the huge energy requirement, which is usually met by coal/electricity/firewood or in combination. The total livestock population in the State has increased from 98.99 lakh in 2003 to 104.73 lakh in 2007, registering an increase of 5.8% [5]. The district wise area and livestock population is presented in Table 2.

2. Potential of renewable energy

The state has a huge quantity of biomass by-products, which can be utilized for electricity generation by the use of solar energy, biogas, gasification technologies, etc. The Ladakh region gets approximately 320 days of sunshine for a year and is one of the best places in the world for solar cooking. The cost of providing kerosene, LPG or even firewood is very high due to higher transportation cost (i.e. 20–25% more than Jammu region). It has added advantage of widespread use, non-polluting nature and inexhaustible supply over other fuels. In the case of diesel sets, the fuel has to be transported from the plains. Due to the region's remoteness, the cost



Fig. 2. Map of Jammu region of J&K state showing different agro-climatic zones.

Table 1
Agro climatic zones and livelihood production system in J&K State.

Zones	Climate altitude (m, amsl)	Livelihood production system	District representing the zone
Zone I	Sub tropical 200–800 m	Agriculture, Livestock Fish, Horticulture	Jammu and plains of Samba, Kathua and Udhampur Districts
Zone II	Intermediate/sub-humid 801–1500 m	Agriculture-Horticulture Livestock Fish	Hilly area of Doda, Udhampur, Reasi, Ramban, Rajouri and Poonch Districts
Zone III	Temperate 1501–2200 m	Agriculture-Horticulture Livestock-Pasture-Fish	Srinagar, Budgam, Anantnag, Pulwama, Baramula, Kupwara, Leh and Kargil districts
Zone IV	High temperate/cold arid >2200 m	Livestock-Silvipasture-Agriculture	Leh-Ladakh and Kargil districts

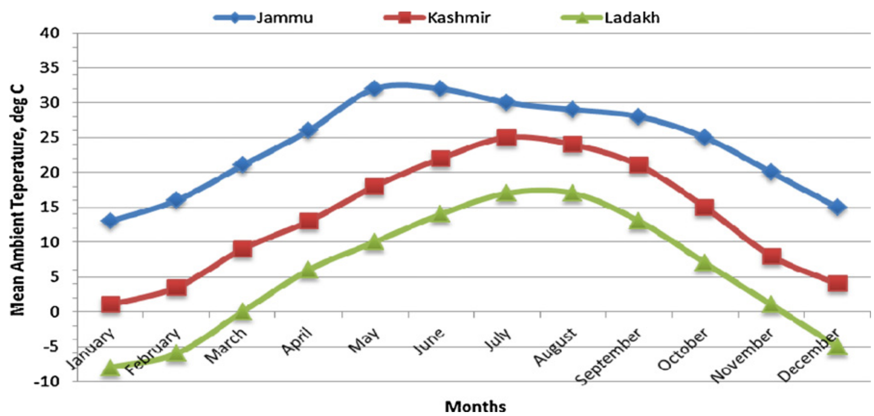


Fig. 3. Mean ambient temperature data (2006–2010) in the different regions of J&K state.

Source: Refs. [35–37].

Table 2
Area, livestock and hydropower status of different districts of J & K State.

Districts	Area (km^2)	Livestock	Hydropower (MW)
Anantnag	2917	6.75	3
Kulgam	1067	[a]	N.A.
Pulwama	1086	3.695	N.A.
Shopian	312	[a]	N.A.
Srinagar	1183	2.564	N.A.
Ganderbal	1045	[a]	120
Budgam	1371	5.289	N.A.
Baramulla	4190	6.948	105
Bandipora	398	[a]	22.6
Kupwara	2379	3.174	2
Leh	82665	3.991	7.8
Kargil	14036	2.52	4.5
Jammu	2336	7.487	N.A.
Samba	910	[a]	N.A.
Udhampur	2473	16.168	32.8
Reasi	1700	[a]	N.A.
Doda	2985	15.053	1
Ramban	1346	[a]	N.A.
Kishtawar	7737	[a]	N.A.
Kathua	2502	7.435	9
Rajouri	2630	11.811	N.A.
Poonch	1674	8.108	N.A.

Refs. [34,5].
[a] Newly formed districts: data incorporated in the parent districts.

of transportation maintenance as well as the cost of generation per unit is very high. The profit on investment in renewable energy will increase by several percentage points, or to be more precise from 19 to 24%, while the current rate of return is between 16 and 19%. The technology like solar thermal systems which includes solar driers, solar water heaters stream and dish colors and solar green houses and other renewable energy efficient technology have been promoted in the state (Table 3). Though, the state government has provided electricity to almost all the villages for lighting but due to inadequate supply of electricity and severe cold climate particularly in Kashmir and Ladakh region, fuel wood and coal is also being utilized by the villagers, resulting in deforestation and degradation of land. Renewable energy can play an important role in meeting the increasing demand for energy in the state. Unique in the world, India has the only Ministry that is dedicated to the development of renewable energies: the Ministry of Nonconventional and Renewable Energy (MNRE), which is devising action plans for application of renewable energy projects to J&K state where the demand for electricity is increasing with each passing day [6]. The Government of India also encourages foreign investors to set up power projects based on other non-conventional energy sources [7].

Table 3
Status of the installed renewable energy resources in Jammu & Kashmir State.

S.no.	Type of system	Quantity installed distributed (nos.)
1.	Solar Lanterns	16,797
2.	Solar Street Lights	5,496
3.	Solar Home Lighting Systems	15,677
4.	Solar Power Plants	04
5.	National Programme on Improved Chulhas	4,50,000
6.	Solar Photovoltaic Pumps	04
7.	Solar Sprayers	14
8.	Solar Fans	12
9.	Solar Water Heating Systems (of varying capacities)	163
10.	Solar Stills	34
11.	Solar Cookers	
	(i) Domestic	1439
	(ii) Community	60
12.	Solar Dryers	09
13.	Solar Timber Seasoning Kilns	02
14.	Wood Gasifiers	08
15.	Biogas Plants	2128
16.	Wind Monitoring Stations	05
17.	Compressed Soil Block Making Machine	100
18.	Fuel Less Pumps	02
19.	Energy Parks	07
20.	Water Mills (Modernized)	07
21.	Micro Hydel Projects	01
22.	Battery Operated Vehicles (BOVs)	05
23.	Fuel Efficient Bhukharies	5

Source: Refs. [13,14,30].

3. Potential of wind energy

The wind energy industry is one of the fastest growing sectors. More than 100 countries are actively pursuing wind energy continuously, though considered as a moderate wind regime, India has excellent wind speed suitable for micro wind turbines across several parts of the country and stands at the fifth spot in terms of installed wind energy capacity.

Tamilnadu, Gujarat, Maharashtra, Goa, Rajasthan, Madhya Pradesh, Jammu and Kashmir, Uttarakhad, Himachal Pradesh, Arunachal Pradesh, coastal Orissa, Andhra Pradesh, Karnataka, are considered to be some of the best zones for micro wind turbines (www.ehandsenergy.in). Jammu and Kashmir State is fairly untapped in the field of wind energy however there is a significant scope of harnessing wind energy in different districts

Table 4
Wind energy potential in different districts of Jammu & Kashmir.

S.no.	District	Wind energy potential (kWh)
1.	Leh	7000
2.	Udhampur	5000
3.	Anantnag	5000
4.	Baramulla	5000
5.	Kupwara	5500

www.ehandsenergy.in.

(Table 4). These energy of wind mills can be very effectively used for water lifting and electricity generation.

4. Potential of solar energy

The per cent share of electricity for agricultural consumption is 3.48% (Table 5) Renewable energy sources account for a share of just 8% of the total energy generation and 4% in total electricity generation in India [8,9]. If only 10% of solar radiation (1 kW/m^2 surface) is harnessed in the state at 10% conversion efficiency, 0.01% surface area of total geographical area has the potential to generate 2.22×10^9 MW energy, which will be sufficient for domestic energy requirement of the farmers in the state [10].

Solar energy can be an important source for the state which presently gets electricity either through its hydel projects or through diesel sets. This solar energy can be effectively adopted for heating, cooking, lighting, refrigeration, drying of grain and farm produce, etc. Solar power systems usually yield an initial return on investment of 7–11% [11]. Solar energy is also an investment which is inflation-protected because it offsets electricity costs at the current prevailing retail rate. As utility rates increase, with an ever increasing demand for electricity, returns will also increase. In fact, the hot weather in most of India (including J&K) has recently led to a significant increase in electricity prices on the Indian Energy Exchange (IEX) and Power Exchange India (PXI). These are between Rs 6 and Rs 8 per unit and in the near future the cost of solar power generation in India is said to come down to Rs 5–6 per kilowatt hour/unit [9]. The solar power is very effective in electrifying the remote villages which may otherwise involve huge investment in laying power transmission lines. As part of the Central Governments' Remote Village Electrification (RVE) programme, solar energy-powered, electrical lighting systems were introduced in September 2009 in about 3900 households in 27 remote villages of the Gurez tehsil. Projects have also been sanctioned for extending basic-lighting facility to 145 of the 284 un-electrified villages and 28 hamlets in the state [12]. Solar thermal systems such as solar driers, solar water heaters, steam and dish cookers, and solar green houses have been promoted in the state. Presently there are 389 street lighting system and 15,317 home lighting systems in the state [13].

The sale and after sale repair and maintenance of solar power equipments is a big issue in the region because of topography and low population density. In order to overcome this problem 10 Akshay Urja shops has been sanctioned by the Government in the districts of Jammu, Kishtwar, Srinagar, Anantnag, Bandipora, Baramulla, Ganderbal, Shopian, Kupwara and Budgam. These Akshay Urja shops not only sells and repair renewable energy and energy saving devices but also provides the information about availability of various renewable energy sources [14]. The solar cooker market though existent has not been tapped to its full potential in the state as it gets approximately more than 250 clear sunny days in a year though there are limitations of being a dilute source and intermittent in nature, solar energy has the potential for meeting and supplementing various energy requirements. Being modular in nature solar energy can be installed in any capacity [15]. Even the banking sector in the state is also exploring feasibility of setting up 200–300 solar powered ATM's in state to boast solar power utilization. Photovoltaic solar lights, solar power plants, grid connections and water heating systems are being provided under the programme of Jawaharlal Nehru National Solar Mission nearly 9250 solar lanterns have already been distributed in remote and far flung areas of the state [16].

Table 5
Electricity consumption for agricultural purposes.

	Jammu & Kashmir	India
Electricity consumption for agricultural purposes (kWh)	145.90	90,292.40
Total electricity consumption (kWh)	4188.54	417,886.9
Per cent share of agricultural consumption, %	3.48	21.97

Ref. [39].

The problem with solar power is that despite the fact that solar power is 5–11 times more expensive to produce electricity from the sun than it is from coal, hydro or nuclear sources, energy production only takes place when the sun is shining therefore large storage systems are required to provide a constant and reliable source of electricity when the sun during the winter season where most of the days are cloudy in the state. And solar panels while not producing energy takes longer time to recoup their installation and maintenance cost.

The cost of providing kerosene, LPG or even firewood in J&K is 20–25% more than what it is in other parts of the country, and high transportation costs is one of the prime reasons for the differential. Some of the farmers in the state have adopted renewable energy sources for meeting their domestic energy requirements. The Ministry of New and Renewable Energy has planned for large scale use of Renewable Energy with a package of Rs 520 crore which include 30 small/micro hydel projects aggregating to 23.5 MW capacity, 300 SPV power plants of 5–100 kW capacity, 2000 SPV home lighting systems and about 40,000 solar thermal systems such as water heating, solar cookers, solar passive buildings, solar green house [17].

In Ladakh, solar radiation is one of the most abundant natural resources, with annual solar radiation exceeding averages for other areas of country with high insulation [18]. The average daytime ambient temperatures, even in the middle of summer, rarely exceed 27 °C, which means solar PV modules are at their most efficient in producing electricity from the sun [33]. The Ladakh Renewable Energy Development Agency (LREDA), the nodal agency of the MNRE is currently implementing renewable energy technologies across the region. To date, more than 30 companies from across India (many of which are part of global corporations) have put forward proposals for the execution of solar thermal and solar photovoltaic works, e.g. TATA BP Solar and Reliance [19]. Solar water heating system with a collector area of 15,000 m^2 is being covered under the programme (Ladakh renewable energy initiative) sanctioned by MNRE in 2010 [20]. A 100 kVA Solar Power Plant have been installed at Durbuk Block, Ladakh (Fig. 4).

Solar green house dryers are the enclosed area, some means are provided to store the daytime excess heat. Vents are strategically sized and positioned to control air flow. A well designed greenhouse dryer permits a greater degree of control over the drying process than the solar cabinet dryers and should be used where relatively large quantity of product is to be dried (Fig. 5).

The major constraints for less demand and use of renewable energy resources is may be lack of awareness among the rural people, non availability of technical know-how, higher initial cost of installation, varied climatic conditions round the year.



Fig. 4. A 100 kV solar power plant installed at Durbuk Block, Ladakh.

Source: Refs. [40].



Fig. 5. A view of solar green house cum tunnel driers.

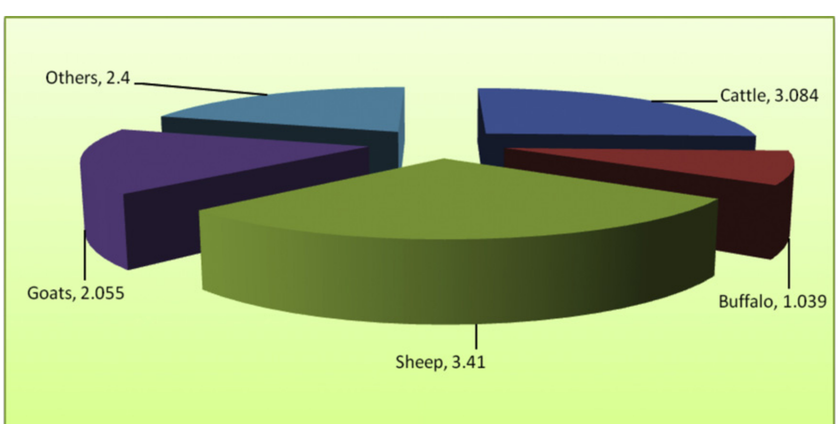
5. Energy from biomass

The potential for application of biomass as an alternative source of energy in the state is extremely high due to the higher capacity factor of biomass than other renewable energy sources as well as availability in abundance of fuel wood, agricultural residues and animal wastes [21]. The plenty of agricultural and forest resources for production of biomass is abundantly available in the state. The average growing stock volume density in Indian forests is about 74.42 m^3/ha, 224.5 m^3/ha in Jammu and Kashmir. The mean biomass density in Indian forests was estimated to be 135.6 tonnes/ha 251.8 tonnes/ha in Jammu and Kashmir, respectively [22]. This biomass can be very effectively converted into energy using pyrolysis and gasification technologies.

6. Status and potential of biogas technology

More than 2/3rd of state population derives its livelihood from the agriculture sector and use agricultural residues and cattle dung cakes for cooking as fuel, which is a wasteful practice and hardly 9–12% of the fuel value is harnessed [23]. The burning of cattle dung has not only led to national wastage of organic manures but has also health and environmental hazards. Similarly the manure that is left to decompose in open releases two main gases that cause global climate change: nitrous dioxide and methane. Nitrous dioxide (NO_2) warms the atmosphere 310 times more than carbon dioxide and methane 21 times more than carbon dioxide. One cow can produce enough manure in 1 day to generate three kilowatt hours of electricity whereas only 2.4 kilowatt hours of electricity are needed to power a single one hundred watt light bulb for 1 day.

Participation in biogas technology varies across socio-economic groups, and across regions. Biogas technology though having numerous advantages yet the potential has not be fully tapped [24]. Energy for cooking alone contributes 50% of the total energy budget



(Source: Ministry of Agriculture, 2003)

Fig. 6. Principal livestock population (lakh) in J&K state.

Source: Ref. [38].



Fig. 7. The Floating drum type Biogas plant at vill. Athena Distt. Budgam.

of the state. There is a large potential for the application of biogas technologies to provide sustainable power supplies for distributed generation. The livestock population of the state is estimated to be 104.73 lakh (Fig. 6) and even if 60% of this livestock provides 5 kg dung/livestock/day, it will be sufficient to operate about 12.56 lakh family size biogas plants of size 2 cubic meters. The biogas thus generated will be sufficient to fulfill the needs of more than 104.67 lakh persons, thereby saving more than 4188.84 million tons of fuel wood and besides huge amount of biogas digested sterilized manure will be available for use in the crops. Thus, biogas itself will be a milestone in self-reliance on energy with saving forest. At present there are 2128 biogas plants installed in J&K state [13] the majority falling in the Jammu region since the Kashmir region is under temperate climatic condition and the feasibility of biogas plant is thin during the severe winter conditions. Three main considerations (i.e. purely anaerobic conditions in digester, proper carbon:nitrogen ratio and operating temperature) are essential for satisfactory gas production.

Therefore for temperate regions where the temperature is very low during winters, the use of biogas technology is totally different from that of plains. The low temperature has a deleterious effect on methanogenesis and can cause decreased gas yields and digester failure [25]. As the biogas plants did not have heating provision and automatic control of temperature all the operational biogas plants in Kashmir valley are reported non functional and out of order in winter. The maximum gas yield is obtained in mesophillic range, more precisely when the temperature is between 30 °C and 35 °C [26]. Development of appropriate designs of biogas plant to suit the hilly conditions and minimization of low temperature problem are of more concern to the Agricultural Engineers. Sher-e-Kashmir University of Sciences & Technology of Kashmir, Srinagar (SKUAST-K) with the financial assistance from Department of Science & Technology, Govt. of India has designed and developed the biogas technology for the temperate climatic region for round the year production of biogas (Fig. 7). Four model biogas plants have been installed at four villages of Kashmir region, i.e. Village Chralpora Rohama, Rafiabad, District Baramulla, Village Athena, District Budgam, Village Mulnar New Theed, Harwan, District Srinagar. Village Chak-i-Safapora, District Ganderbal [23].

7. Geo-thermal energy

India has reasonably good potential for geothermal which can produce 10,600 MW of power. But yet geothermal power projects has not been exploited at all, owing to a variety of reasons, the chief being the availability of plentiful coal at cheap costs. However, with increasing environmental problems with coal based projects, India will need to start depending on clean and eco-friendly energy sources in future, one of which could be geothermal. Similarly, the State has a high potential for geo-thermal energy. It is estimated that around 40 MW of power can be obtained from this source and exploitation of the same can ease the power situation in the region [27]. The state has also set targets to electrify the remaining un-electrified villages by non-conventional energy mode. A 40 kW solar power plant has been installed in Ladakh through which 500 households are being provided electricity. It has been a success, having reduced the consumption of diesel to provide power. The central government is planning to launch 100 MW geo-thermal projects in Reasi and other feasible areas of Jammu & Kashmir to boost up the renewable energy sector of the state. Under the Ministry of New & Renewable Energy electrification of 68 villages has been sanctioned. The villages included in this scheme are Anantnag, Kulgam, Budgam, Ganderbal, Pulwama and Shopian among others. From geochemical and deep geophysical studies (MT) conducted in Puga Valley in J&K, it has been estimated to have a reservoir temperature of 240 °C at 2000 m. Harinarayana [28] also estimated the potential of as much as 40 MW in Puga Valley of Southeast Ladakh.

8. Watermills and micro hydel projects

Jammu and Kashmir is one of the states of India which is having tremendous hydro-power potential. It has a long history of Hydel power projects, the 2×4.5 MW Mohra Hydro electric plant was developed as early as 1905. The major rivers and their perennial tributaries can effectively be utilized for domestic energy requirements through water mills and small-scale hydroelectric units. Ironically the state is endowed with huge hydro power potential but the development in this sector has not been commensurate because of shortage of financial resources and the Indus Water Treaty signed between India and Pakistan. This treaty prohibits reservoir storage of water on the major rivers of J&K restricting the scope of generating electricity from hydro power to generation from only run off the river projects [29].

The state had an installed power capacity of 2263.6 MW consisting of 1093.3 MW of state share and 1170.3 MW of central share. The estimated hydel potential in J&K is more than 20,000 MW, of which projects for 16,480 MW have already been identified [30]. Two Micro Hydel Schemes of 10 kW and 15 kW are proposed to be

set up at Sarbal and Nilgrath in Kangan area of district Ganderbal by the National Institute of Training and Consultancy (NITCO-NGO) [14].

The major hydroelectric power plants in the state are Uri Hydroelectric Dam (480 MW), Dulhasti (390 MW), Salal (690 MW) and Baglihar (450 MW). The Uri hydroelectric power station is established on the Jhelum River near Uri in Baramula district. This station is largely built under a hill with a 10 km tunnel. The Dulhasti hydroelectric power plant is established in Kishtwar district on the swift-flowing Chenab River in the Doda region [31]. This project provides peaking power to the Northern Grid with the neighboring beneficiary states Punjab, Haryana, Uttar Pradesh, Uttarkhand, Rajasthan and Delhi. The Baglihar hydroelectric power project is a run-of-the-river power project on the chenab river in the southern Doda district with a volume of 1,800,000 m^3 and crest elevation of 844.5 m [32].

The hydel power plants remain closed for months together during winters due to freezing of water and in summers due to high siltation. Inadequate and erratic supply of electricity through the existing hydel projects and diesel sets, absence of conventional fuels like coal and ignite along with the environmental hazards of using energy based on these resources make the option of solar energy attractive. Water wheels, commonly known as 'gharats', have traditionally been used in the Himalayan regions for rice hulling, milling of grain and other mechanical applications. These water mills are normally of very old design and work at very low efficiencies. Steps have taken up by the state owned agencies to improve their efficiency.

In order to encourage private investment in hydro-projects, 23 states including Jammu and Kashmir have announced policies for setting up commercial small hydro power projects through private sector participation. The facilities available in the States include wheeling of power produced, banking, buy-back of power, facility for third party sale, etc. There are 2 projects with aggregate capacity of 17.5 MW in the private sector.

9. Energy parks

Jammu and Kashmir is likely to get nine solar power plants and four district level energy parks of different capacity for generating awareness about use and promotion of renewable energy. The work on 14 solar power plants and 4 District Level Energy Parks at various health and educational institutions is going on. MNRE has sanctioned the grant for installing 11 solar water heating systems, 210 solar street lights and 5 wind hybrid systems with an aggregate capacity of 46 kWs and two sites for study of wind regime at different locations in the state [14].

10. Conclusion and recommendations

Jammu and Kashmir is a region with immense potential for renewable energy projects. Considering the region's vast potential to harness renewable resources and to promote clean energy, investment in this sector promises high returns, there is an essential need for encouraging corporate sector to increase their investment in renewable energy by providing higher returns on their investments. The government has already established Akshay Urja shops and has announced policies for setting up commercial small hydro power projects through private sector participation. There is also a need for the union government to make it mandatory for all states in India to enter into a renewable purchase obligation (RPO) agreement which would require every state to purchase a fixed per cent of their energy needs from renewable energy plants. The engineers/scientists and developmental agencies of government and NGO's should work on this aspect of non-traditional energy resources for the development of eco-friendly, farmers friendly and user friendly power generation system. The micro hydel projects having short gestation period will prove to be economical beneficial and most environmental friendly in long run. These projects can bring sustainable energy to the state. It is urged that cooperative and constructive efforts are required for efficient harnessing of renewable energy.

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